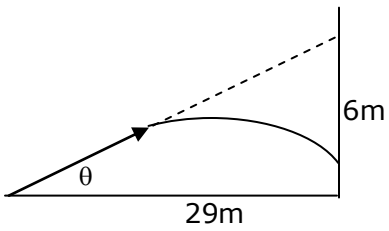
Projectile Motion

Q 1 - A man standing **29 m** from the base of a vertical cliff throws a ball with a speed of **38 m/s** aimed directly at a point **6 m** above the base of the cliff.

a) How long does it take the ball to reach the cliff?
b) Neglecting air resistance and the height of the man, calculate the height above the base of the cliff at which the ball hits.
c) How fast is the ball moving when it reaches the cliff?
d) At what time does the ball reach its largest vertical height?
e) At what horizontal distance from the man does the ball reach its largest vertical height?

As the ball is thrown pointing at a point 6m above the baseline the direction of the ball thrown makes an angle such that tan θ = 6/29 or the angle is 11.68940.



Hence the horizontal components of the velocity is given by
$V_0 * \cos\theta = 38 * \cos 11.68940 = 38 * 0.9763 = 37.2119$ m/s

And the vertical velocity component will be
$V_0 * \sin\theta = 38 * \sin 11.69 = 38 * 0.2026 = 7.6990$ m/s

The acceleration in horizontal direction is zero and the vertical acceleration is g = - 9.8 m/s/s.

a) How long does it take the ball to reach the cliff?

The horizontal distance to be covered is 29 m and the horizontal velocity is $v_0 \cos\theta$ is constant, hence the time taken to reach the cliff is given by

t = distance/velocity = 29/37.2119 = 0.7793 s.

b) Neglecting air resistance and the height of the man, calculate the height above the base of the cliff at which the ball hits.

The vertical displacement in this time in vertical direction is given by, as in direction acceleration is g

$[s = ut + (1/2)\, at^2]$

$y = v_0 * \sin\theta * t + (1/2)(-9.8)t^2$

or $y = 7.6990 * 0.7793 - 0.5 * 9.8 * 0.6073 = 5.99983 - 2.97597 = 3.0233$ m

c) How fast is the ball moving when it reaches the cliff?

The horizontal velocity remains constant $Vx = v_0 * \cos\theta = 37.2119$ m/s
And the vertical velocity after time t is given by
$[v = u + at]$

$Vy = v_0 \sin\theta + (-9.8)t$
Or $Vy = 7.6990 - 9.8*0.7793 = 0.0618$ m/s (almost zero)

Hence speed or magnitude of velocity

$$V = \sqrt{37.212^2 + 0.0618^2} = 37.21195 \text{ m/s}$$

v = 37.21195 m/s

d)At what time does the ball reach its largest vertical height?

The time for largest vertical height is given by the time when the vertical velocity is zero and hence
$Vy = v_0 \sin\theta + (-9.8)t$
Or $0 = 7.699 - 9.8*t_1$
Or $t_1 = 0.7856$ s

e)At what horizontal distance from the man does the ball reach its largest vertical height?

The horizontal distance covered in this time t_1 is
X = velocity * time = 37.2119*0.7856 = 29.2337 m
